MOCU

Multi-robot Operator Control Unit

Space and Naval Warfare Systems Center
San Diego
Code 2371

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Multiple UxV Control

- MOCU designed from ground-up to control multiple heterogeneous vehicles
- MOCU is not tied to any specific vehicle, vehicle type or protocol
- Modularity, scalability and flexible display enable control of a wide range of vehicles

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Modularity

- Major functions and interfaces implemented in loadable “modules”
- Modules are various types, such as
  - Map modules
  - Protocol modules
  - C2 modules
  - Media modules
- Incorporating new functionality often involves just creating a new module
- Modules can be written by any developer
- Core provides base functionality and glue to tie modules together

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Modules

C2 Link Modules
JUSC2 UVCC (Spartan)
Composeable Forcenet (CFn)

Protocol Modules
JAUS
MRHA
iRobot PackBot
STANAG 4586

Map Modules
CADRG
CIB
DNC
GeoTIFF

MOCU Core

Media Modules
MJPEG
MPEG
H.263
IndigoVision codecs

Planner Modules
Comms
Mission
Path

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Scalability

- Modularity allows MOCU to scale to requirements
- Only required modules are loaded
- Allows MOCU to run on small embedded systems, laptops or racks

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Flexible User Interface

- Displays and robot controls determined by configuration files
  - Define desired gauges, buttons, maps and video windows
  - Map hardware/joystick control
- Configuration can be robot-specific or generalized to class, model manufacturer, domain or protocol

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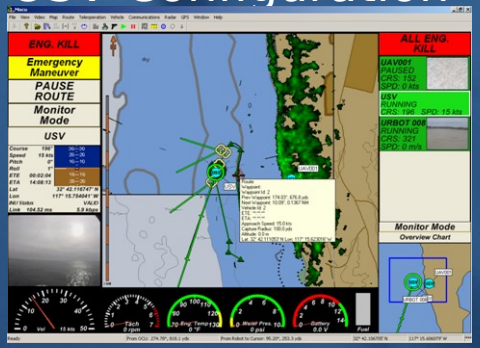
Interface Configurations

Several different display configurations below illustrate how MOCU can be configured for different UxVs without re-compiling any software

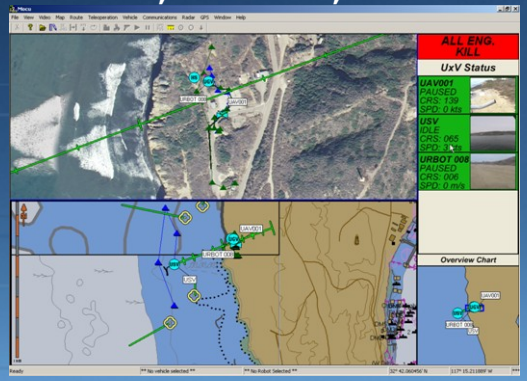
UGV Configuration

USV Configuration

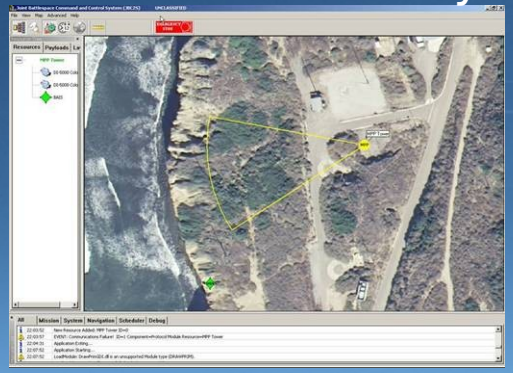


UAV Configuration

Monitor Mode
1 UGV, 1 UAV, 1 USV



Perimeter Security



FIRRE Configuration

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SPARTAN Overview

- Screenshots
- JAUS protocol
- Low-level control
- Vehicle status
- Waypoint and routes
- Radar contacts and image
- Higher level C2 interface

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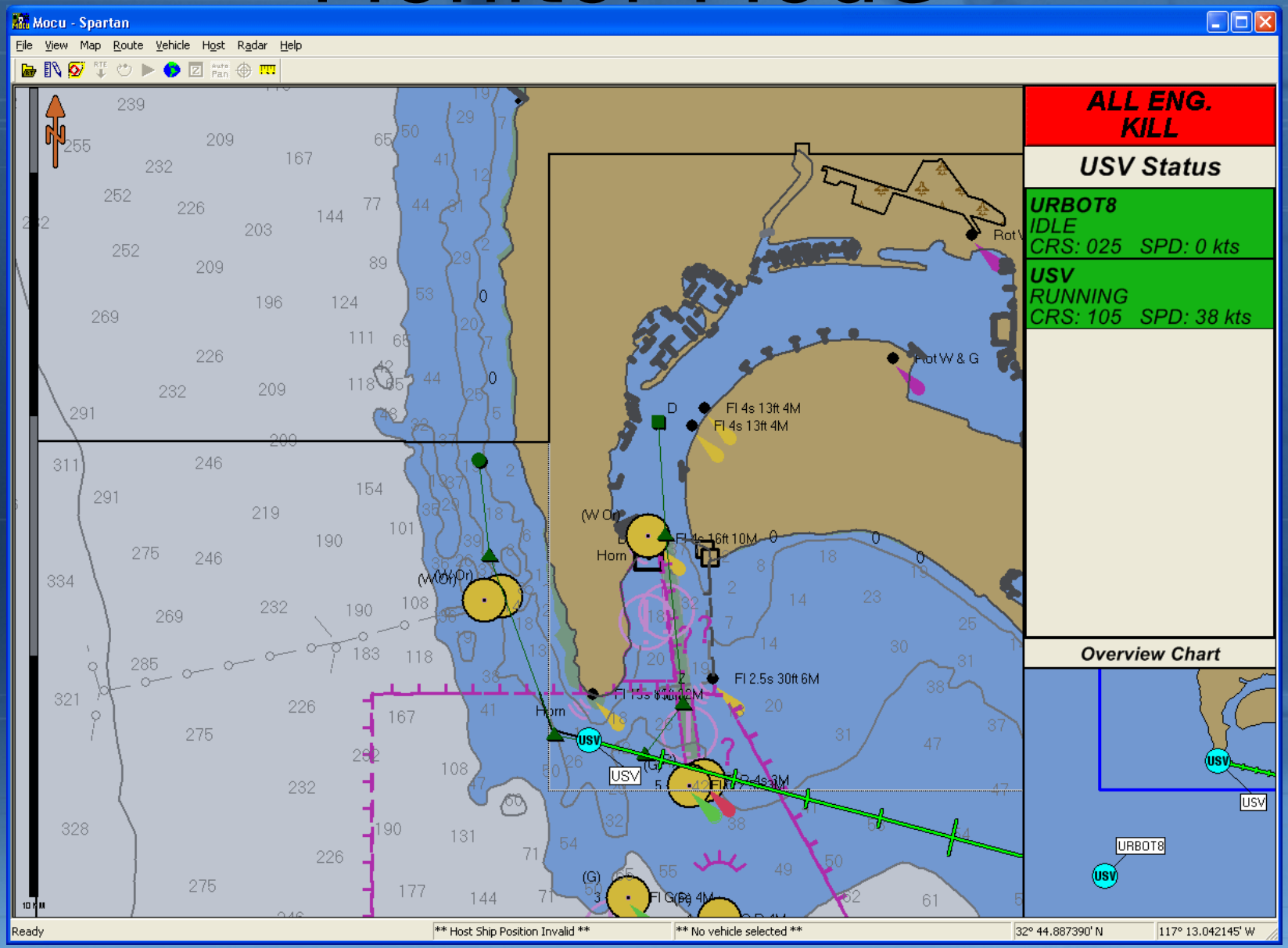
Monitor Mode



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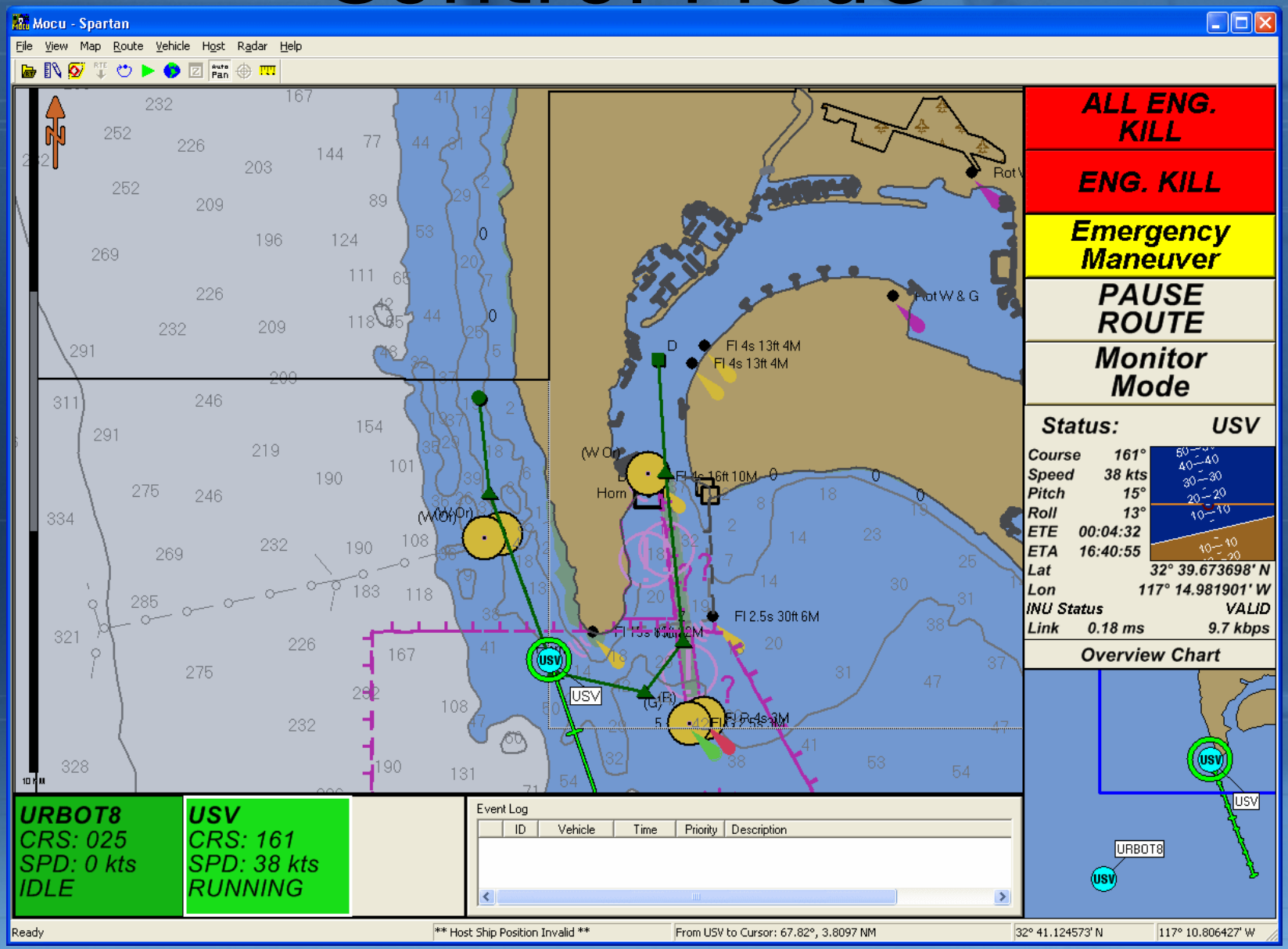
Control Mode



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Vehicle Interface Protocol

- Uses the Joint Architecture for Unmanned Systems (JAUS) protocol
- Mandated by PEO-LMW for all UGV, UUV and USVs

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Low Level Controls

- RC/Host control
  - RC only
  - Host only
- Emergency Controls
  - Stop current USV
  - Stop all USVs
  - Emergency maneuver action (selectable)
  - Loss of comms action (selectable)

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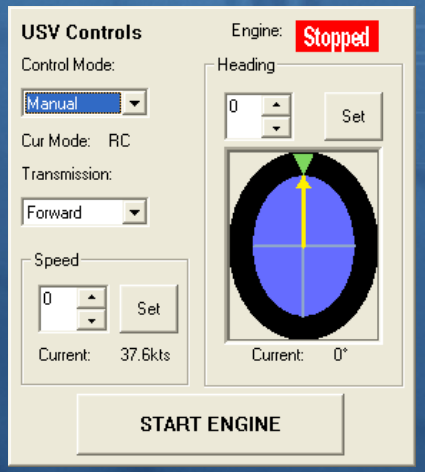
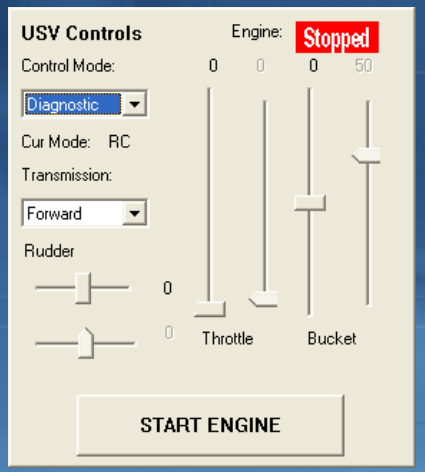
Low Level Controls (cont'd)

- Direct access to vehicle controls
  - Start/stop engine
  - Transmission position
  - Bucket position
  - Rudder position
  - Throttle position
  - Speed
  - Heading





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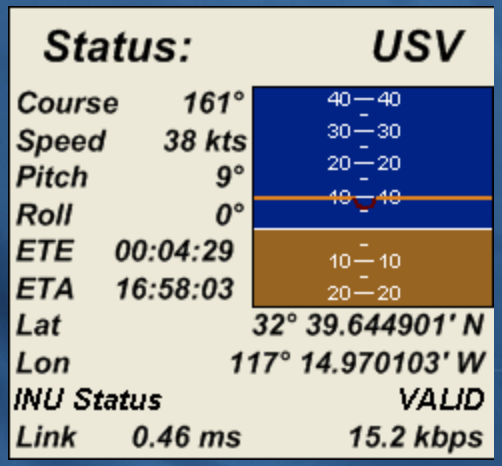
Vehicle Status

- Automatic update and display of following USV status:
  - Position
  - Speed Over Ground
  - Course Over Ground
  - Pitch
  - Roll



- Other status data available but not displayed (e.g. fuel, battery, engine temp, etc.)

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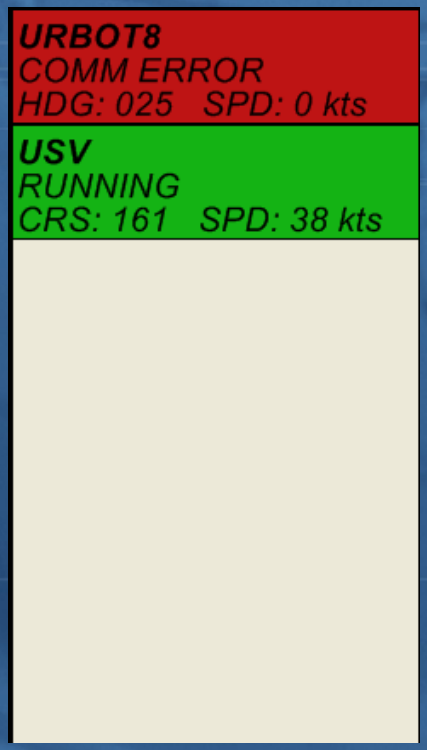
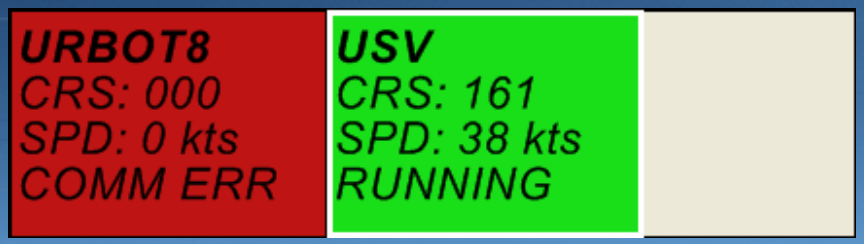
Status Summary

- Shows at-a-glance status of all vehicles
- Color coded for quick critical error check

Monitor Mode



Control Mode



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Operator Machine Interface

- Resolution independence
- Electronic chart display
- Route display/modification
- Operational areas/exclusion zones
- Radar overlays
- Vehicle status displays

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Electronic Chart Display

- MOCU uses the Common Geospatial Navigation Toolkit (COGENT) as the charting engine
- COGENT already supports:
  - DNC and S-57
  - Radar image overlay and ARPA contacts

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Electronic Chart Display

- Chart can be zoomed with keyboard or zoombox
- Chart can be panned with arrow keys or by right-clicking and dragging
- Chart normally automatically follows current USV (can be overridden)

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Electronic Chart Display

- The following are shown on the chart:
  - Host Ship location
  - USV locations
  - Routes/waypoints
  - ARPA contacts
  - Radar image
  - Operational Areas
  - Exclusion Zones
  - Operator specified symbols (buoys, obstructions, etc.)
  - Obstacle avoidance routes

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Vehicle Icons

- Leader line indicates vehicle heading and velocity
- Current USV indicated by green circle
- Cursor-over-icon displays vehicle status
- Dashed line drawn to current waypoint

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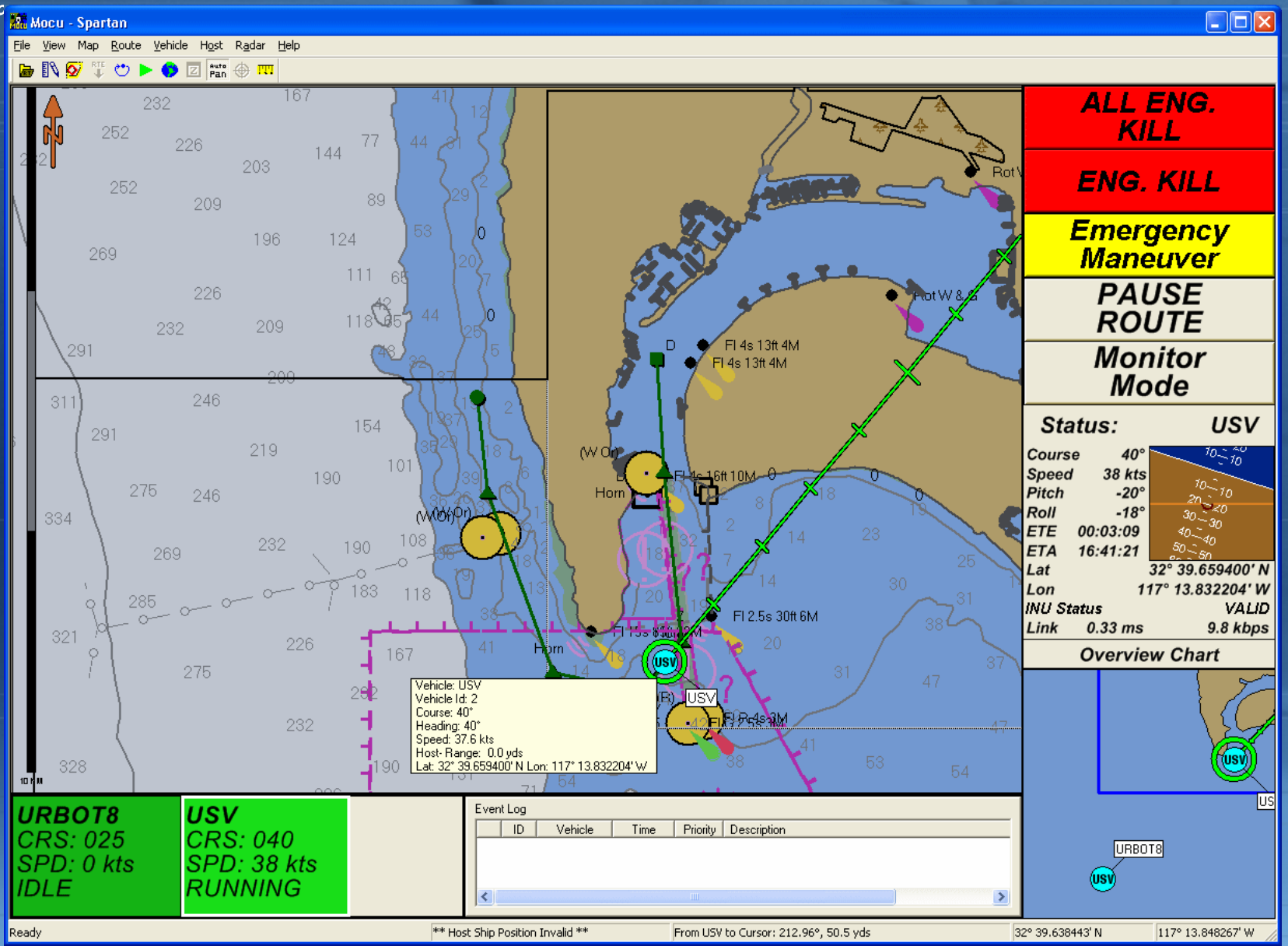
Vehicle Icons



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Routes and Waypoints

- Route/Waypoint control
  - Download routes to vehicle
  - On-the-fly route modification (insert, delete, modify waypoints)
  - Auto route repeat (looping)
  - Stop/resume route execution

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Routes and Waypoints

- Routes can be added by point/click on chart or textually in dialog
- Routes can be loaded from a file
- Routes can be moved, scaled and rotated
- Routes can be named by user
- Waypoints can be moved, inserted, deleted and modified using the mouse

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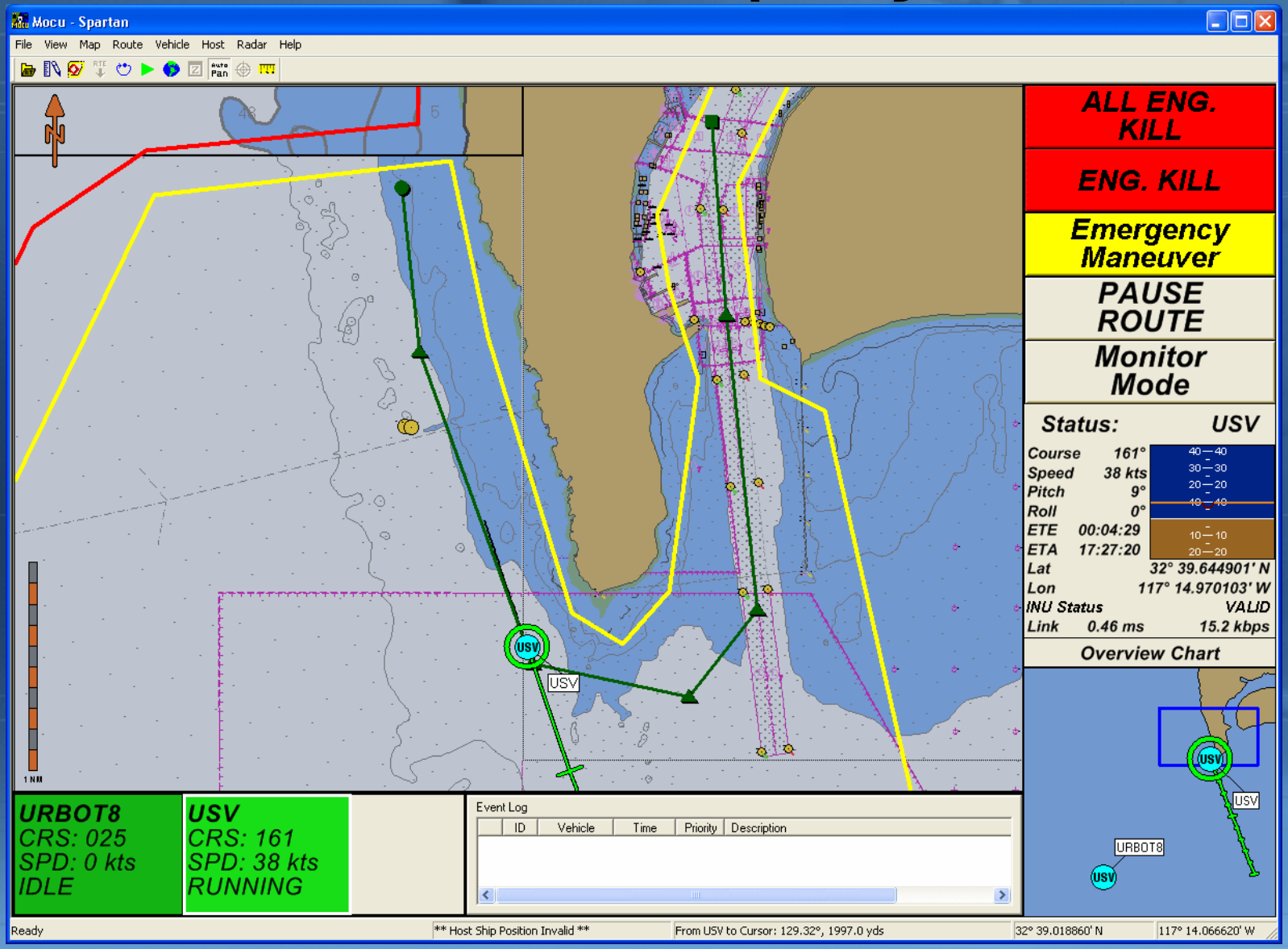
Route Display



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Waypoints

- Waypoints have the following attributes
  - Position
  - Transit speed
  - Capture Radius
  - Action to be performed
  - ID/Name
- Popup display also shows
  - Range and bearing from previous waypoint
  - USV's ETE to this waypoint
  - USV's ETA at the waypoint
- Right-click allows user to change any parameters

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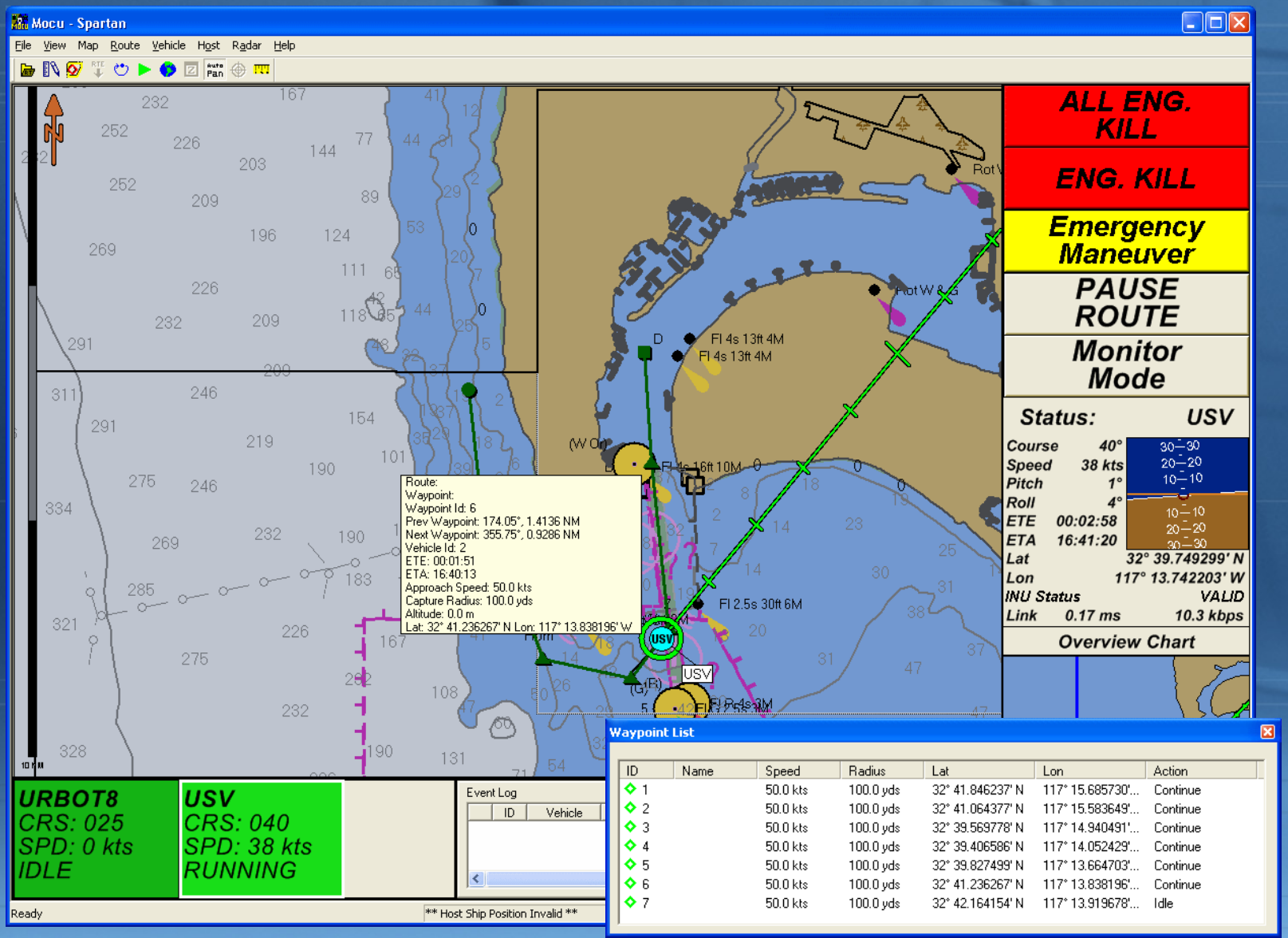
Waypoint Info



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Obstacle Avoidance

- USV OA module sends suggested route to MOCU (displayed in magenta)
- Operator can modify the route
- Operator either accepts or rejects the route
- If accepted USV executes avoidance route
- If rejected USV continues previous route
- OA parameters can be changed by operator

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Operational Areas Exclusion Zones

- Define where USVs are allowed to or prohibited from operating
- Downloaded to USV for use by Obstacle Avoidance module
- Similar to routes, can be drawn or loaded from a file
- Operational areas shown as yellow polygons
- Exclusion zones shown as red polygons

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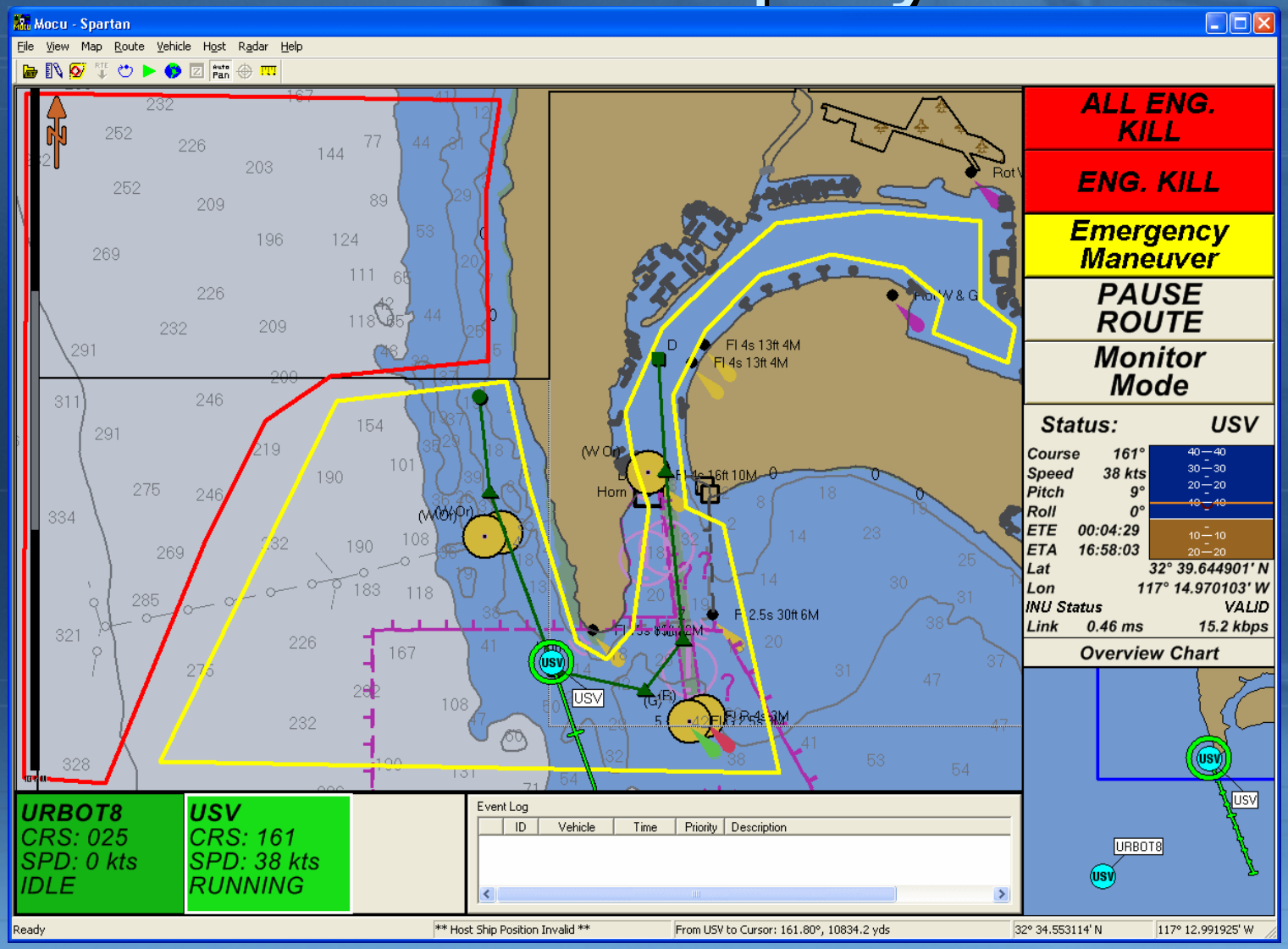
Operational Area and Exclusion Zone Display



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Radar Overlay

- ARPA contacts from each vehicle shown on chart
- Contact info displayed in popup box (cursor-over-icon)
- Operator can name and classify each contact
- Raw radar data from current USV can be overlaid on chart

Radar Display

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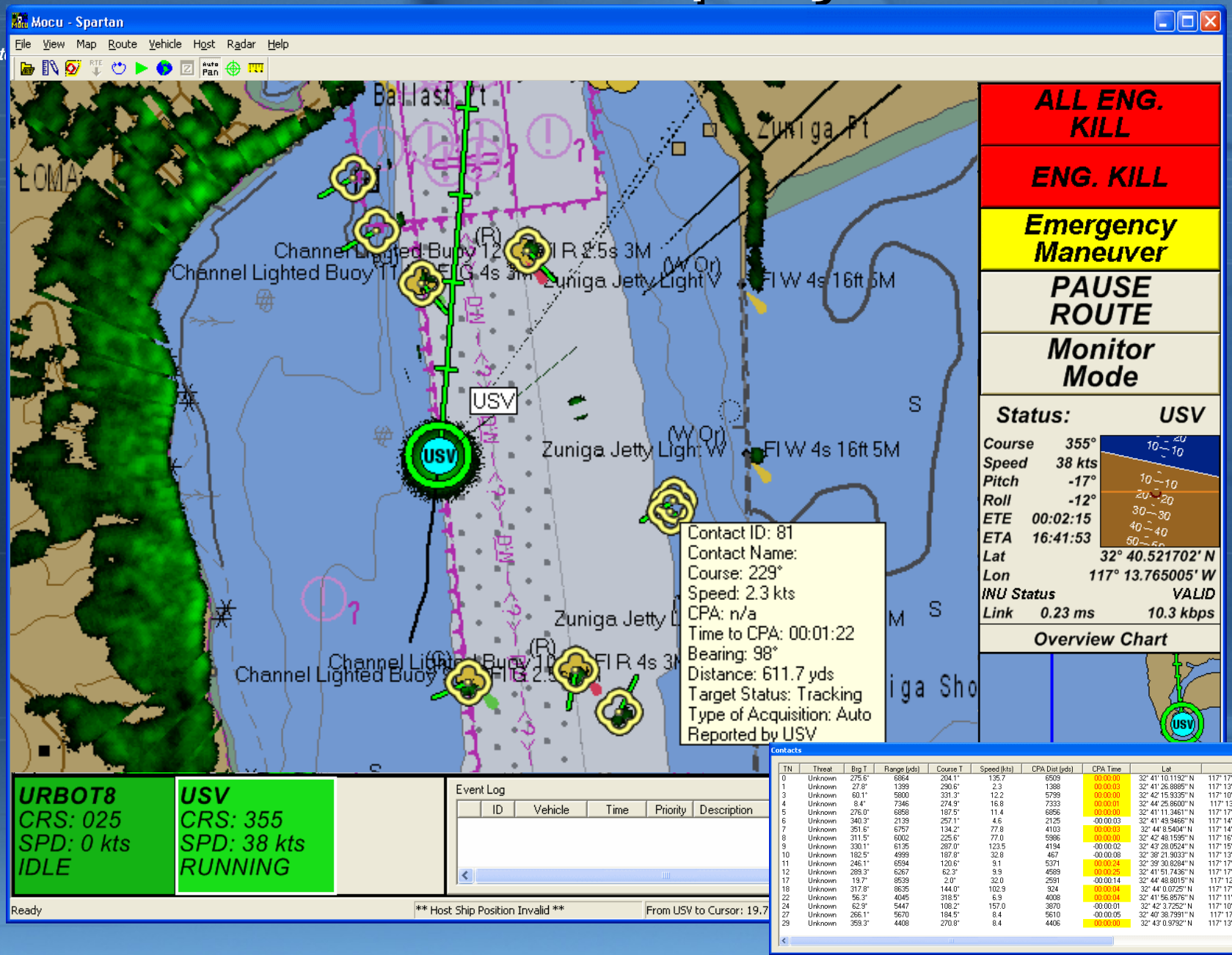

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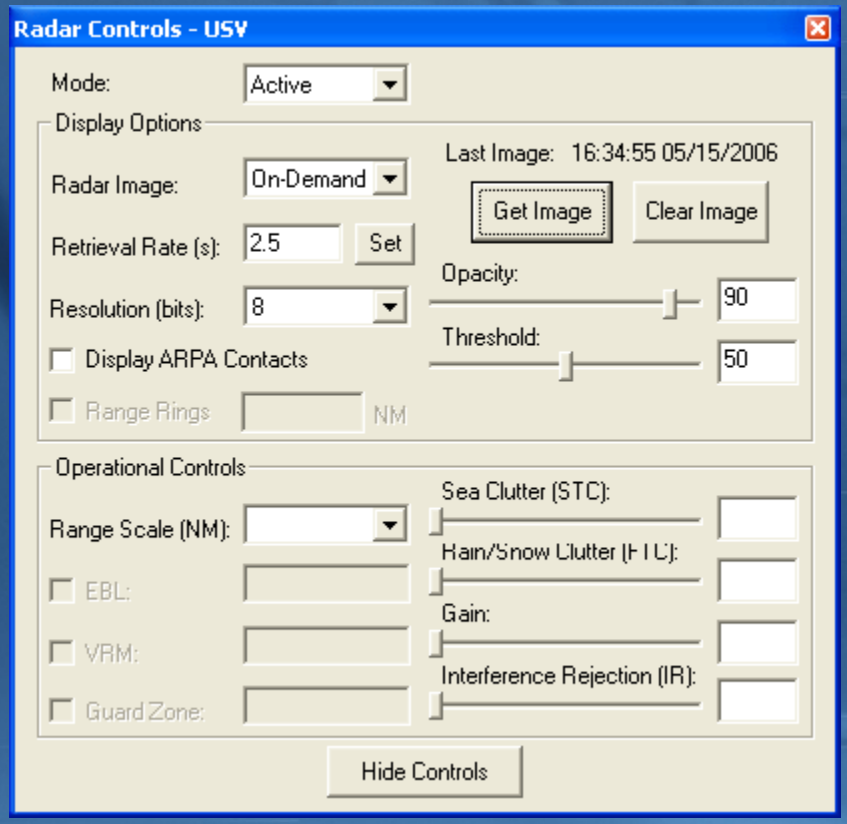
Radar Controls

- On/Off/Standby
- ARPA On/Off
- Radar image On/Off
- STC, FTC, Gain, IR
- Range scale
- Not implemented yet:
  - Electronic Bearing Line
  - Variable Range Markers
  - Guard Zone
  - Range rings



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Higher Level C2 Interface

- SPARTAN required to interface to JUSC2 UVCC
- C2 module provides vehicle positions, routes and contacts to UVCC
- UVCC can send routes to vehicles

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MOCU for LCS ASW

- New modules
- New status
- New controls

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New Modules for ASW

- C2 module to interface to ISS/CMS
  - Receives own ship data (position, speed, heading, route)
  - Imports/exports contact information
  - ISS level 2
  - Written by NUWC
- USV Application Control Module
  - Starts/stops NUWC ASW applications
  - Written by NUWC

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New Status for ASW

- Rates for pitch/roll/yaw
- Heave, surge and sway velocities
- Vehicle acceleration
- Alarm/warning display [TBD]
- Status of the ASW payload
  - Cable length, depth, etc.

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New Controls for ASW

- Camera/spotlight slew-to-cue
- Launch & recovery
  - Hand-off to L&R
  - Re-take control from L&R
- Additional waypoint actions
  - Payload commands

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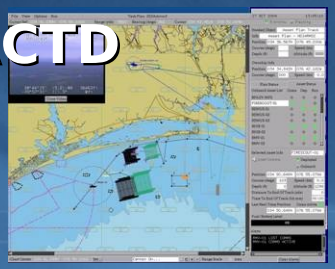
Programs Using MOCU

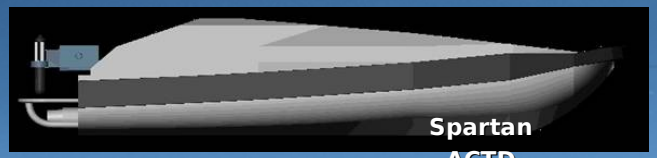
JRP
(UGV, USV, UAV)

FIRRE

U/CAV
ACTD

JUSC2
ACTD





Spartan
ACTD

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Summary

- MOCU is designed to control multiple robots across multiple domains, i.e., UGV, USV, UAV, UUV
- Modular approach enables scalability and expandability
- Flexible user interface allows for robot-specific displays and controls